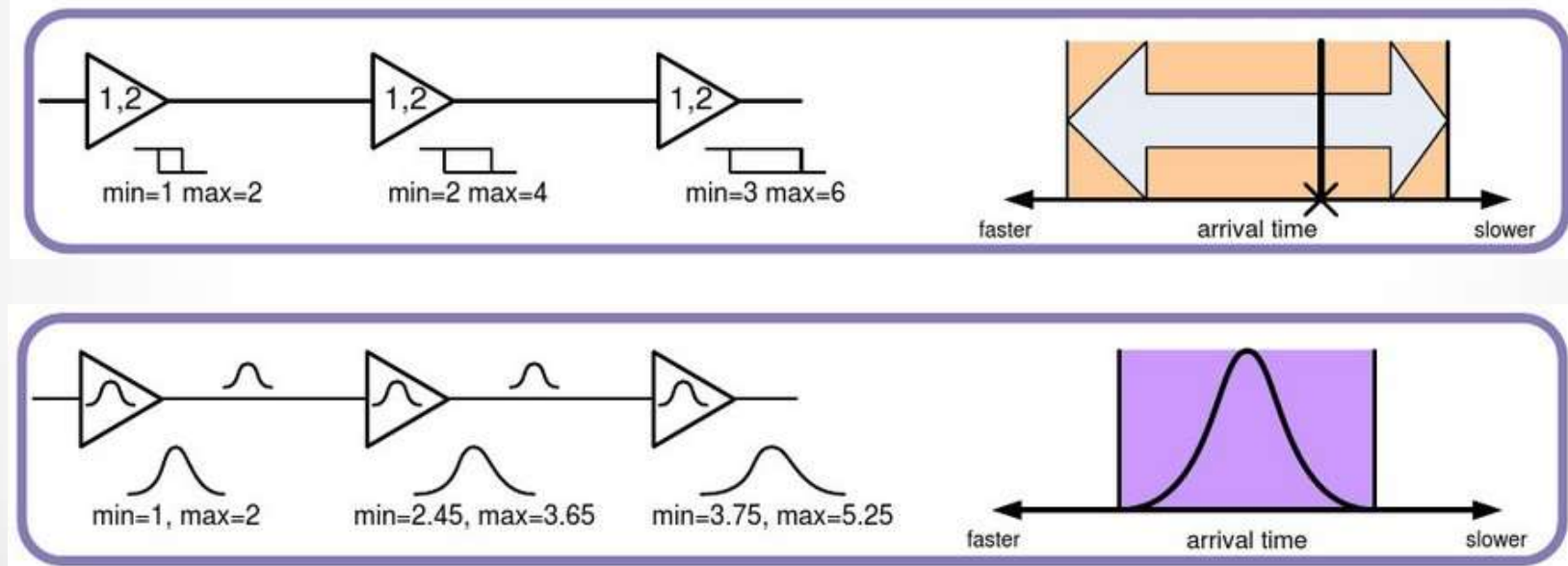


# OCV

- Compared to single operating condition and best case/worst case two timing analysis methods, traditional or global OCV (On-Chip Variation) method has the following advantages:
  - Applies max/min delays on data/clock paths for setup check and min/max delays on data/clock paths for hold check
  - Applies derating to accommodate on chip variation
- Derating setting example:
  - Set\_timing\_derate -early 0.95
  - Set\_timing\_derate -late 1.05

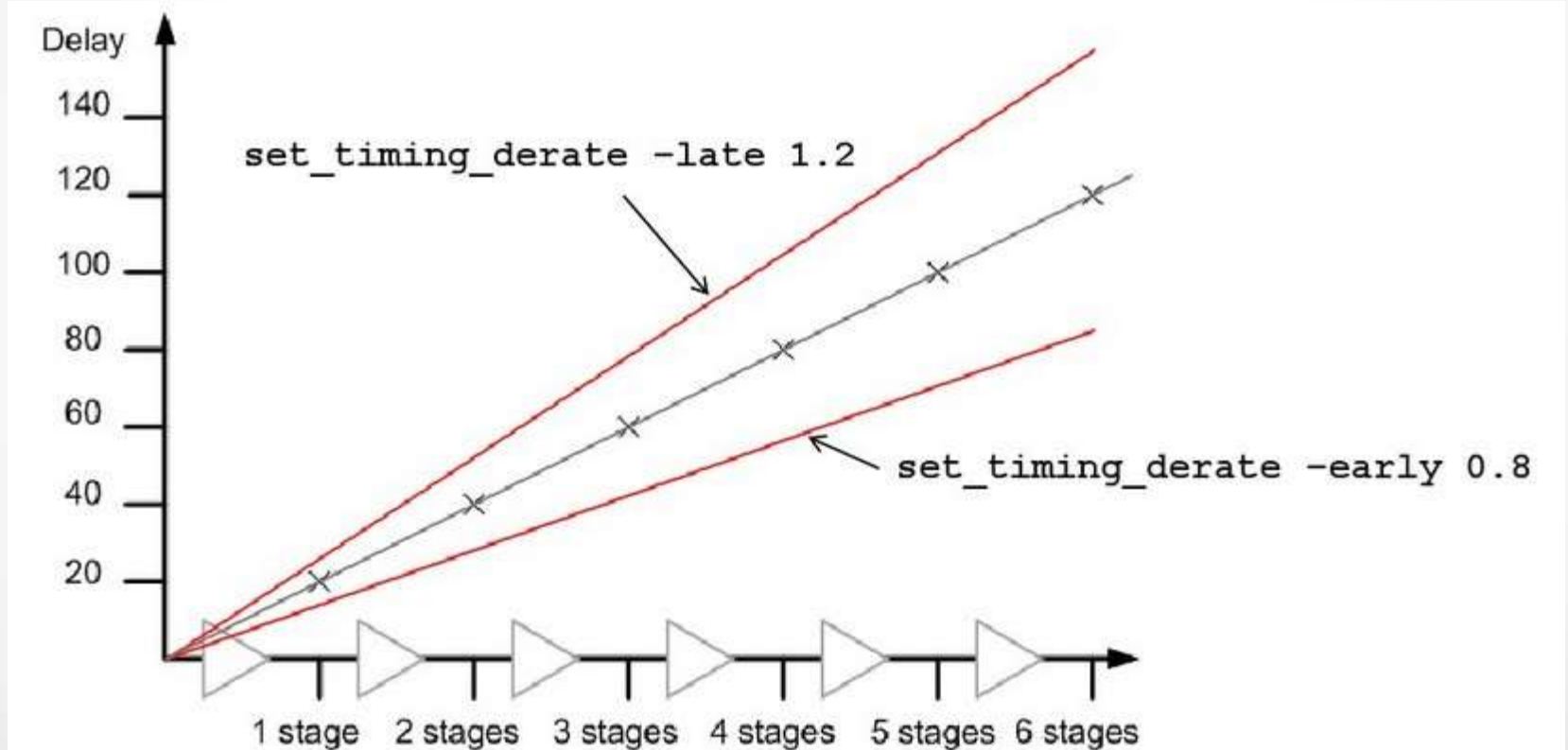
# Global OCV Shortcoming

- However, traditional/Global OCV derating uses worst-case early/late bounds which is too pessimistic
- Real silicon timing is statistical



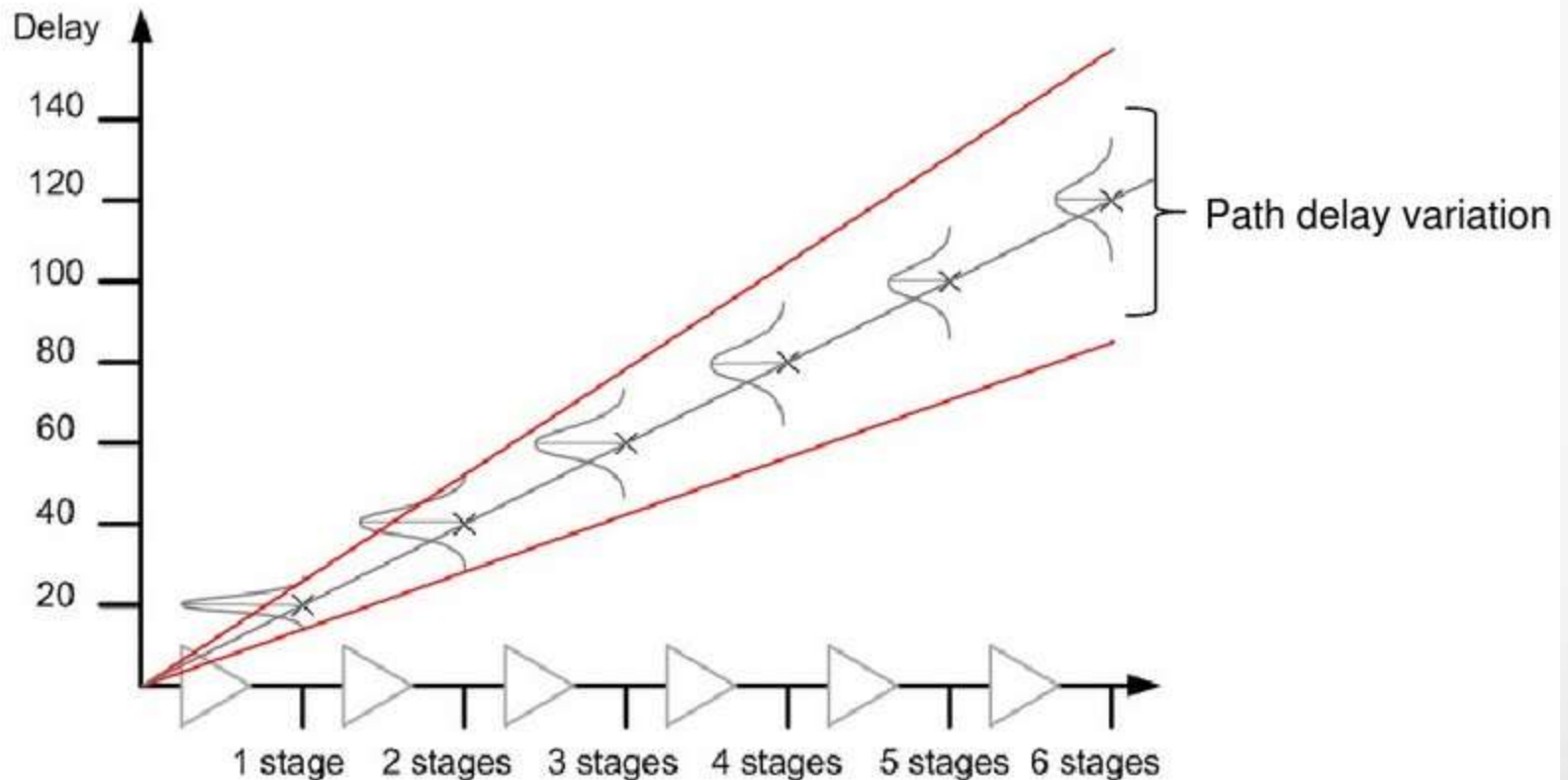
# Fixed Derating with GOCV

- Global OCV applies a fixed % derating to path delay



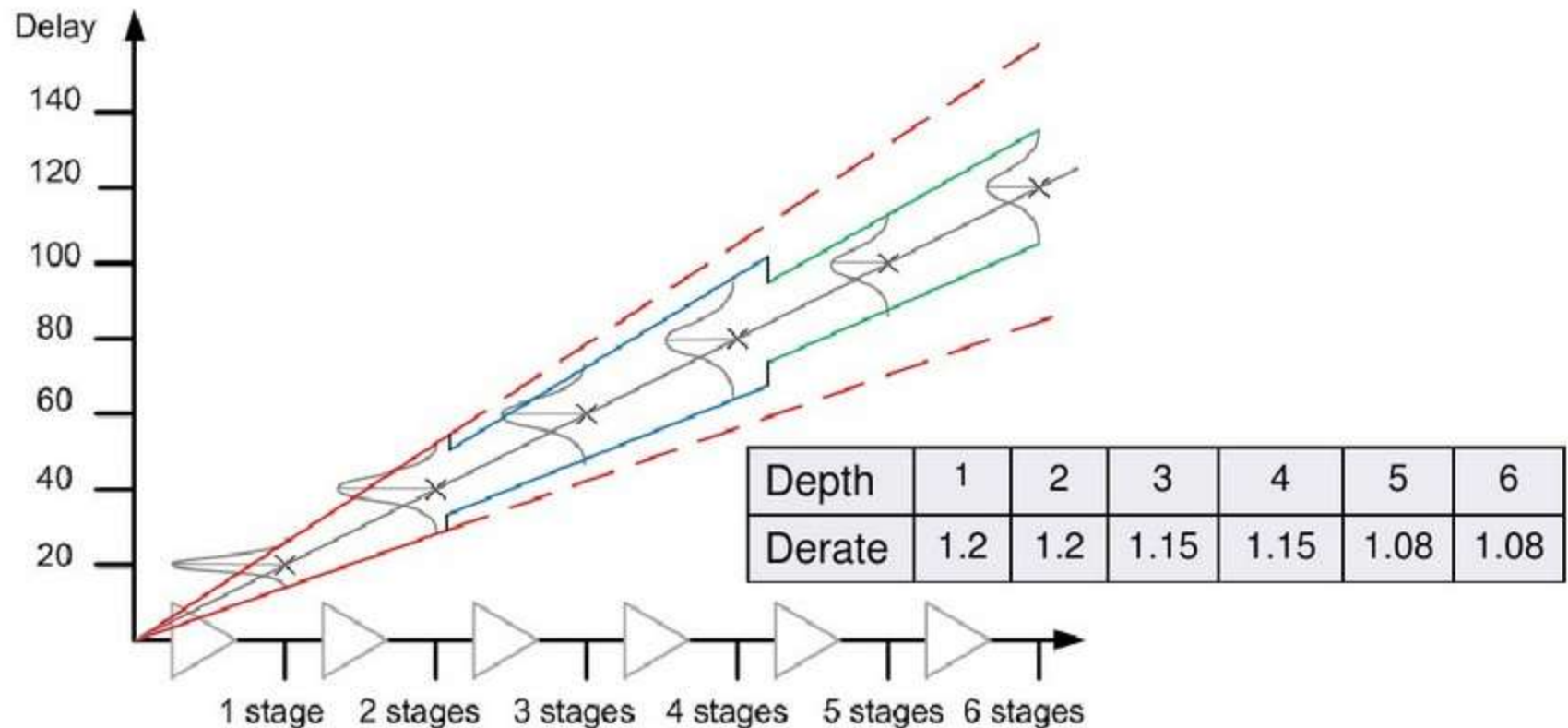
# Statistical Derating I

- In reality random variation is less for deeper timing paths since not all cells are simultaneously fast or slow.



# Statistical Derating II

- Derating factor should be a function of cell depth
- Models on-die random variation
- Deeper paths exhibit less variation than short paths



# 2-D Derating Table

- Derating factor should also be a function of distance/location
- Paths comprised of cells in close proximity exhibit less variation
- Therefore 2-D AOCV derating table

		Depth							
		1	2	3	4	5	10	50	100
Distance	1000	1.130	1.099	1.085	1.078	1.074	1.063	1.055	1.053
	2000	1.130	1.099	1.086	1.079	1.074	1.063	1.055	1.054
	3000	1.131	1.100	1.086	1.079	1.075	1.064	1.056	1.054
	4000	1.131	1.100	1.087	1.080	1.076	1.065	1.057	1.056
	5000	1.133	1.102	1.089	1.082	1.078	1.068	1.061	1.059
	6000	1.135	1.105	1.092	1.086	1.082	1.072	1.065	1.063
	8000	1.137	1.108	1.095	1.089	1.085	1.076	1.070	1.068
	10000	1.140	1.112	1.100	1.094	1.090	1.082	1.075	1.074
15000	1.147	1.120	1.110	1.104	1.101	1.093	1.088	1.087	

Derates Increase with Distance

Derates Decrease for Longer Paths

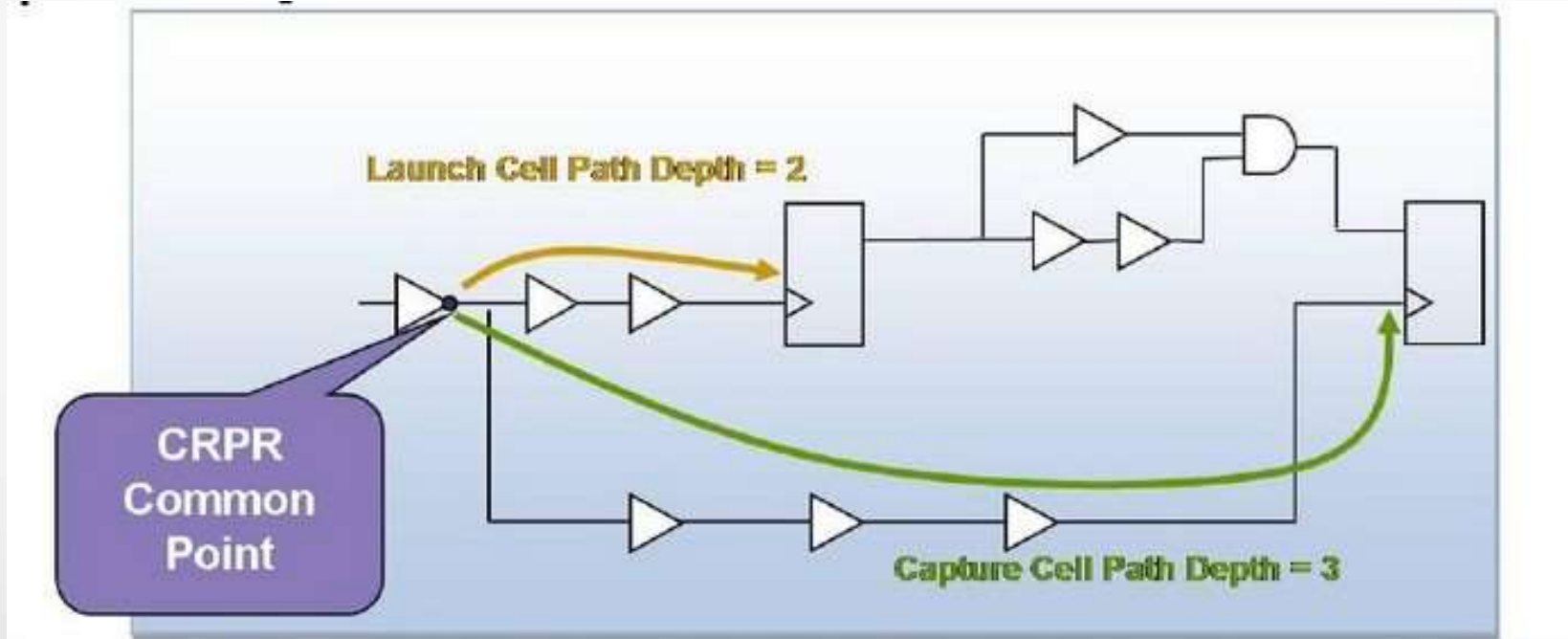
# AOCV Analysis Modes

- AOCV supports clock-only and clock&data AOCV analysis
- AOCV on clock only, Global OCV on data path objects
  - Reduces efforts to generate derating tables
- AOCV on both clock and data
  - AOCV on full design
  - Requires AOCV tables for all design objects



# Depth Computation I

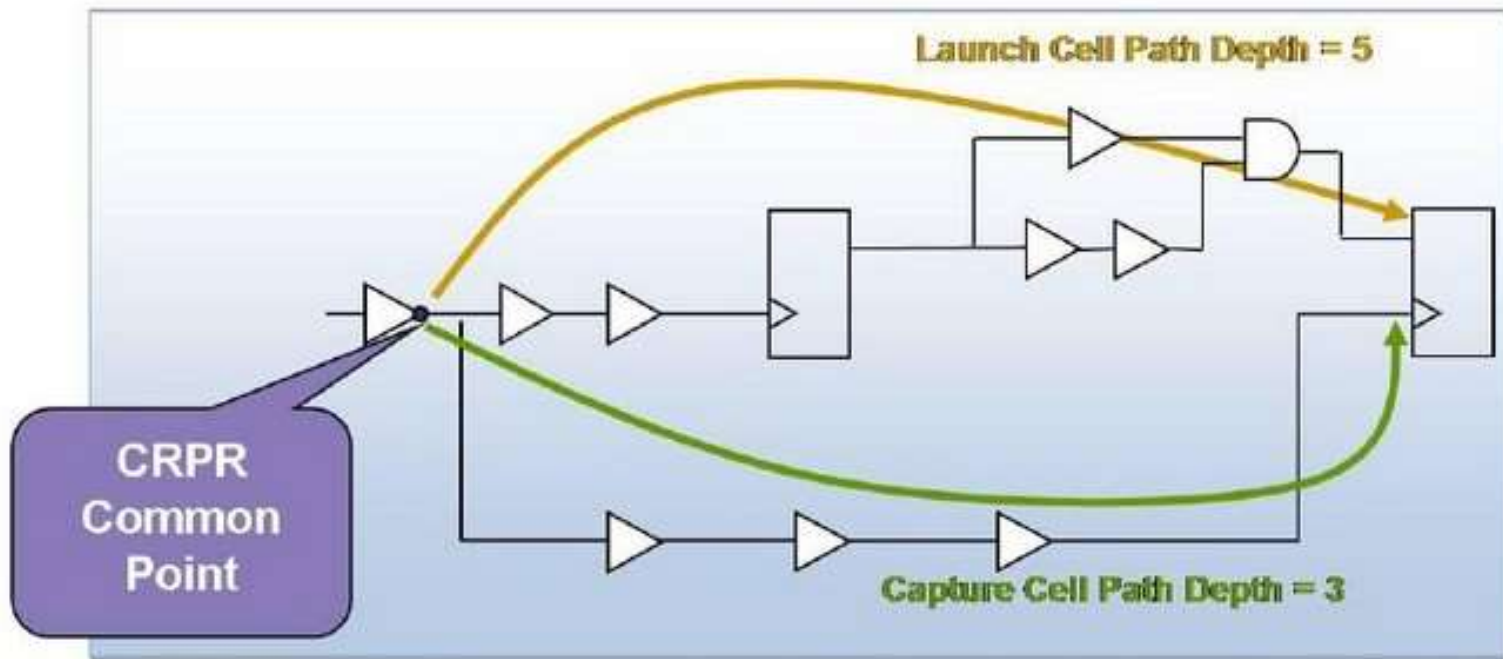
- AOCV on clock network only





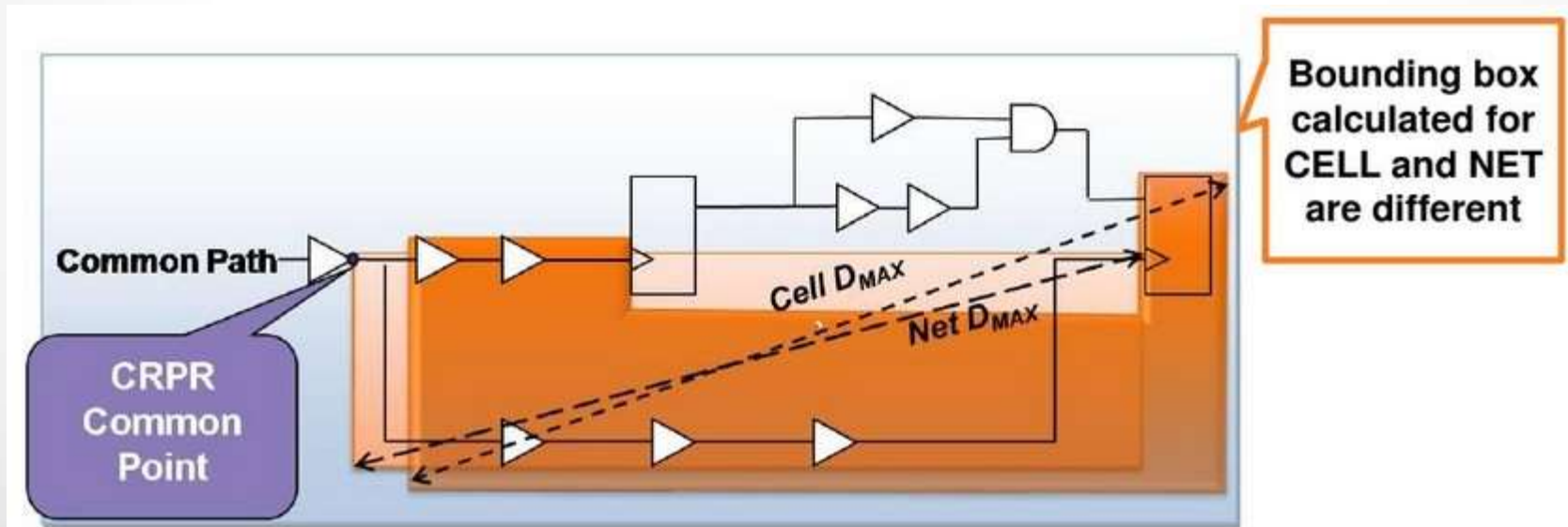
# Depth Computation II

AOCV analysis on both clock and data



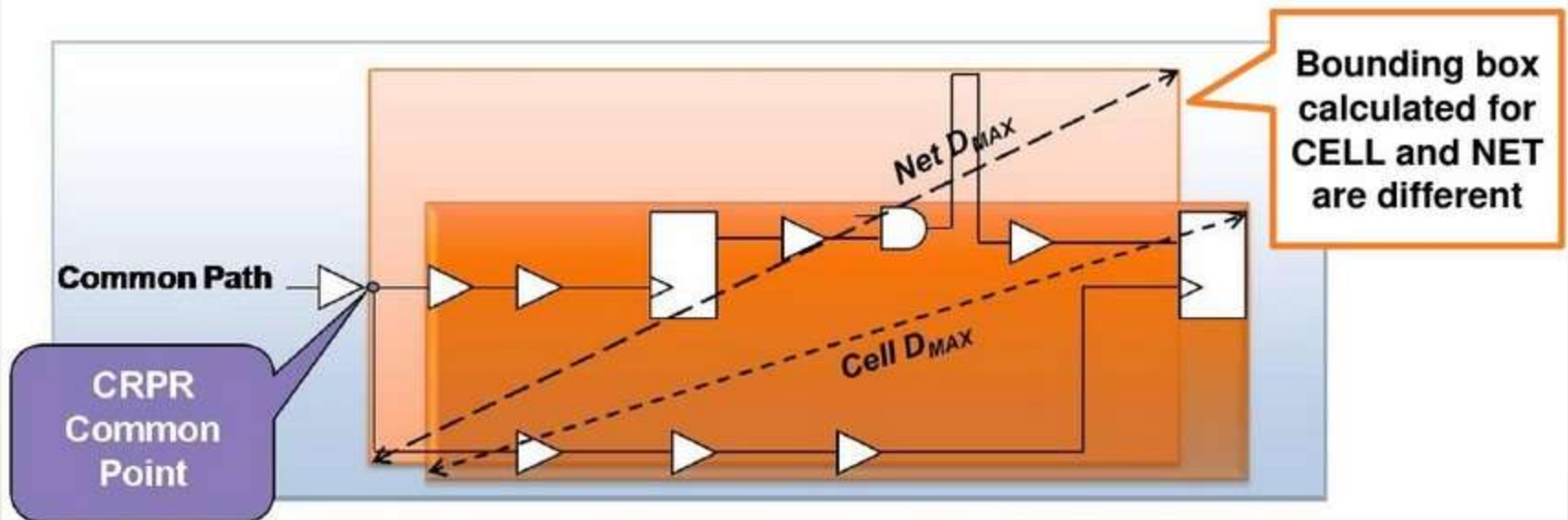
# Distance Computation I

- AOCV on clock only
- Bounding box includes non-common launch & capture clock path objects
- Capturing cell is in cell bounding box



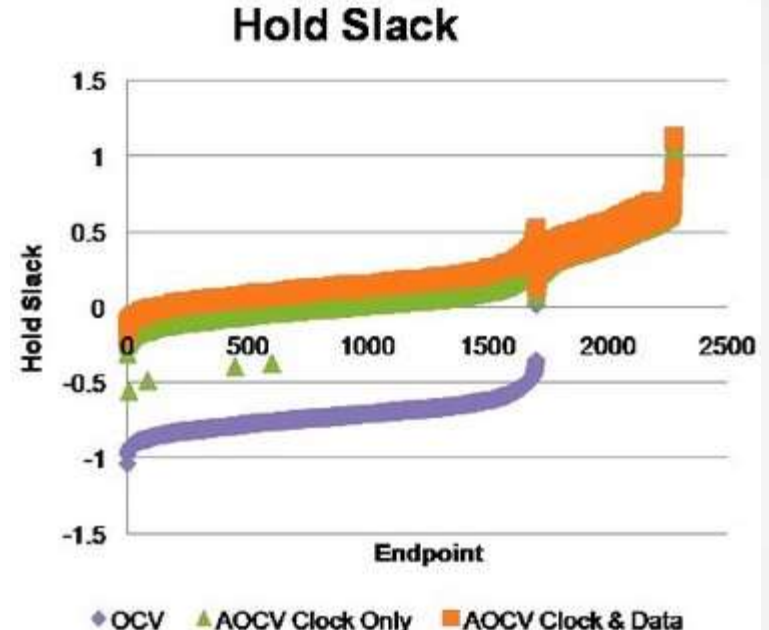
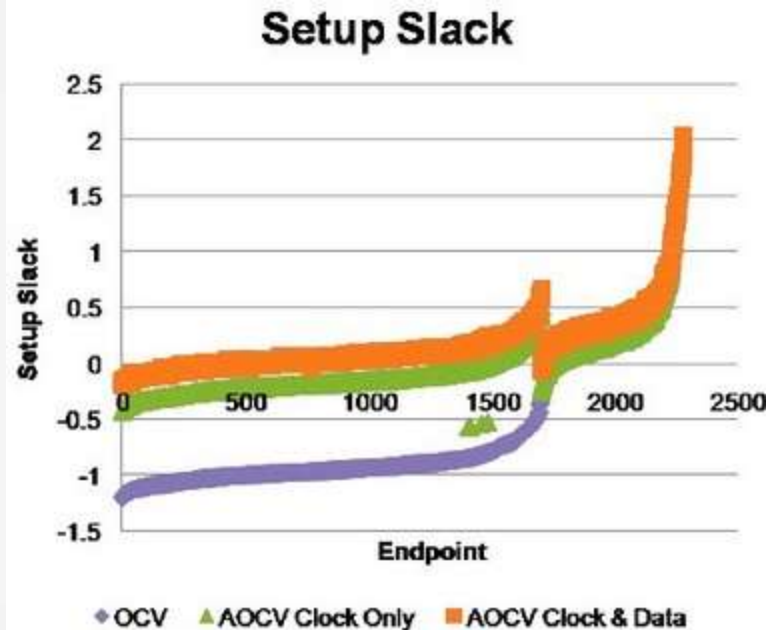
# Distance Computation II

- AOCV on both clock and data
- Bounding box includes non-common launch & capture clock path and data path objects



# AOCV Benefits

- Jarvis' slides shows setup/hold violations are dramatically reduced with AOCV



OCV Method	#violations
Global OCV	1778
AOCV on clock only	1551
AOCV on clock & Data	595

OCV Method	#violations
Global OCV	1704
AOCV on clock only	850
AOCV on clock & Data	176

# Example OCV and AOCV Flow

## OCV Flow

```
#read & link design
Read_verilog ...
link_design

#back-annotate parasitics
Read_parasitics ...

#apply design constraints
Read_sdc ...
Create_clock ...
Set_timing_derate -early 0.80
Set_timing_derate -late 1.20

#Calculate delay & analyze timing
Update_timing

#reports
Report_clock_timing ...
Report_timing ...
```

## AOCV Flow

```
#read & link design
Read_verilog ...
link_design

#back-annotate parasitics
Set read_parasitics_load_locations true
Read_parasitics ...

#apply design constraints
Read_sdc ...
Create_clock ...
Set_timing_derate -early 0.80
Set_timing_derate -late 1.20

Read_aocvm ...
set_timing_aocvm_enable_analysis true

#Calculate delay & analyze timing
Update_timing

#reports
Report_clock_timing ...
Report_timing -derate ...
```

# Configure AOCV

Variable	Description
timing_aocvm_analysis_mode	Specifies the calculation of depth metrics
timing_aocvm_enable_clock_network_only	Applies AOCV analysis to the clock network only
timing_aocvm_enable_single_path_metrics	Specifies whether AOCV analysis uses separate depth and distance values for nets and cells
timing_ocvm_enable_distance_analysis	Specifies whether advanced or parametric on-chip variation analysis performs distance-based analysis
timing_ocvm_precedence_compatibility	Controls the fallback to on-chip variation (OCV) deratings for advanced or parametric OCV

# Enable AOCV

- In summary, to use AOCV, you need to
  - set the `timing_aocvm_enable_analysis` variable to true
  - Use `read_ocvm` to provide tables of derating factors
  - Then you perform timing analysis in the usual manner using commands such as `update_timing` and `report_timing`. The analysis results reflect the application of varying derating factors based on the logic depths and physical spans of the paths.



# Graph and Path based AOCV

- Two AOCV analysis modes:
  - Graph-based AOCV
  - Path-based AOCV
- Graph-based AOCV
  - Fast, design-wide analysis performed during “update\_timing”.
  - Provides a conservative analysis compared t path-based AOCV
  - Prerequisite for further margin reduction using Path-based AOCV
  - For most designs, sufficient for sign-off
- Path-based AOCV
  - Used to reduce pessimism and improve accuracy for violations after Graph-based AOCV
  - To do so, use “report\_timing” with “-pba\_mode” set to “path”
  - pt\_shell> **report\_timing -pba\_mode path**

# Some AOCV Commands

- Use `read_ocvm` to read AOCV derating tables from a disk file. Derating tables are annotated onto one or more design objects and are applied directly to timing arc delays.
- Use the `write_binary_aocvm` to create binary encoded AOCV files from ASCII-format AOCV files. This command is used to protect sensitive process-related information.
- Use `report_timing -derate` to show calculated AOCV derating factors in timing report
- Use `report_aocvm` to display AOCV derating table.
- In a graph-based AOCV analysis, specify a timing arc to show its depth and distance metrics and AOCV derating factors.
  - `pt_shell> report_aocvm [get_timing_arcs -of_objects [get_cells U1]]`

# Multiple AOCV Tables

- AOCV file format supports multiple AOCV derating tables:
  - 1D tables in either depth or distance
  - 2D tables in both depth and distance
- Associate an AOCV table with a group of objects
  - “object\_type design | lib\_cell | cell” or
  - “object\_spec [patterns]”, patterns can use regular expression
- Cell arc derating precedence, from highest to lowest
  - Lib cell, hierarchical cell, design
- Net arc derating precedence, from high to low
  - Hierarchical cell, design

# Incremental Timing Derating

- Incremental timing derating enables you to fine-tune the timing derating factors on objects such as cells or nets
- For example, you might have a u1/u252 cell that has a regular late derating of 1.082 and early derating of 0.924. The final late derating factor on cell u1/u252 =  $1.082 + 0.03 = 1.112$ , and the final early derating factor on cell u1/u252 =  $0.924 + (-0.03) = 0.894$ .
  - `set_app_var timing_aocvm_enable_analysis true`
  - `set_timing_derate -increment -late 0.03 [get_cells u1/u252]`
  - `set_timing_derate -increment -early -0.03 [get_cells u1/u252]`

# POCV

- Parametric OCV (POCV) is the next generation of variation analysis targeted at 14/16nm and below processes. It provides a lightweight statistical margining approach to variation margining. It offers Graph-based Analysis(GBA) pessimism reduction, improved PrimeTime ECO turnaround time, and simpler library characterization than the Advanced OCV approach.
- POCV models the delay of an instance as a function of a variable that is specific to the instance. That is, the instance delay is parameterized as a function of the unique delay variable for the instance.

# POCV

- Compared with AOCV, POCV
  - Reduced pessimism gap between graph-based analysis and path-based analysis
  - Less overhead for incremental timing analysis

